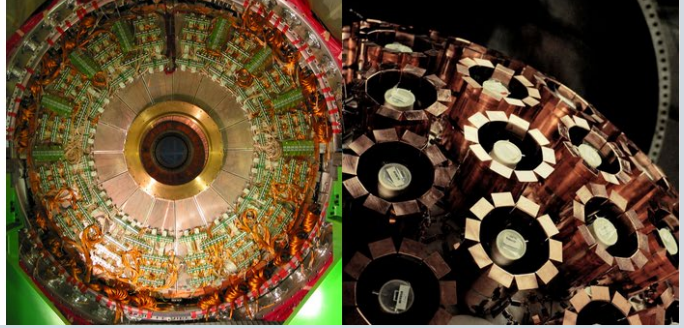
International Conference on Technology and Instrumentation in Particle Physics

May 24-28, 2021 Online format



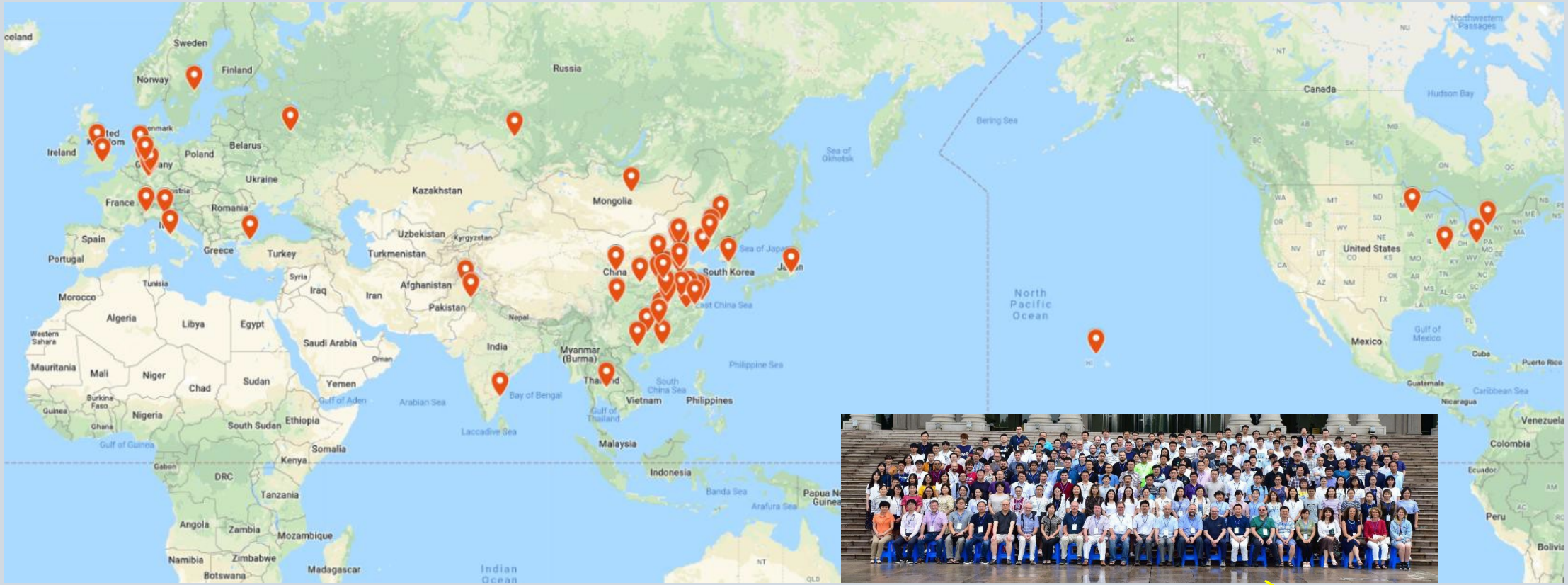
Preliminary results from the cosmic data taking of CGEM detector

MICHELA GRECO, INFN Torino - University of Torino

on behalf of CGEM-IT WORKING GROUP

Istituto Nazionale di Fisica Nucleare
SEZIONE DI TORINO

BESIII Collaboration



INFN FERRARA
Istituto Nazionale di Fisica Nucleare
Sezione di Ferrara

INFN
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

INFN PERUGIA

INFN TORINO
Istituto Nazionale di Fisica Nucleare
Sezione di Torino

15 countries, 72 institutions ~500 members

BESIII Italian Collaboration

Beijing Electron Positron Collider

LINAC

BESIII

BEPCII

See Weimin Song's talk
https://indi.to/XFxjS

Construction started: 1984

BEPC 1989-2005

L_{peak}=1.0x10^{31} /cm^{2}s

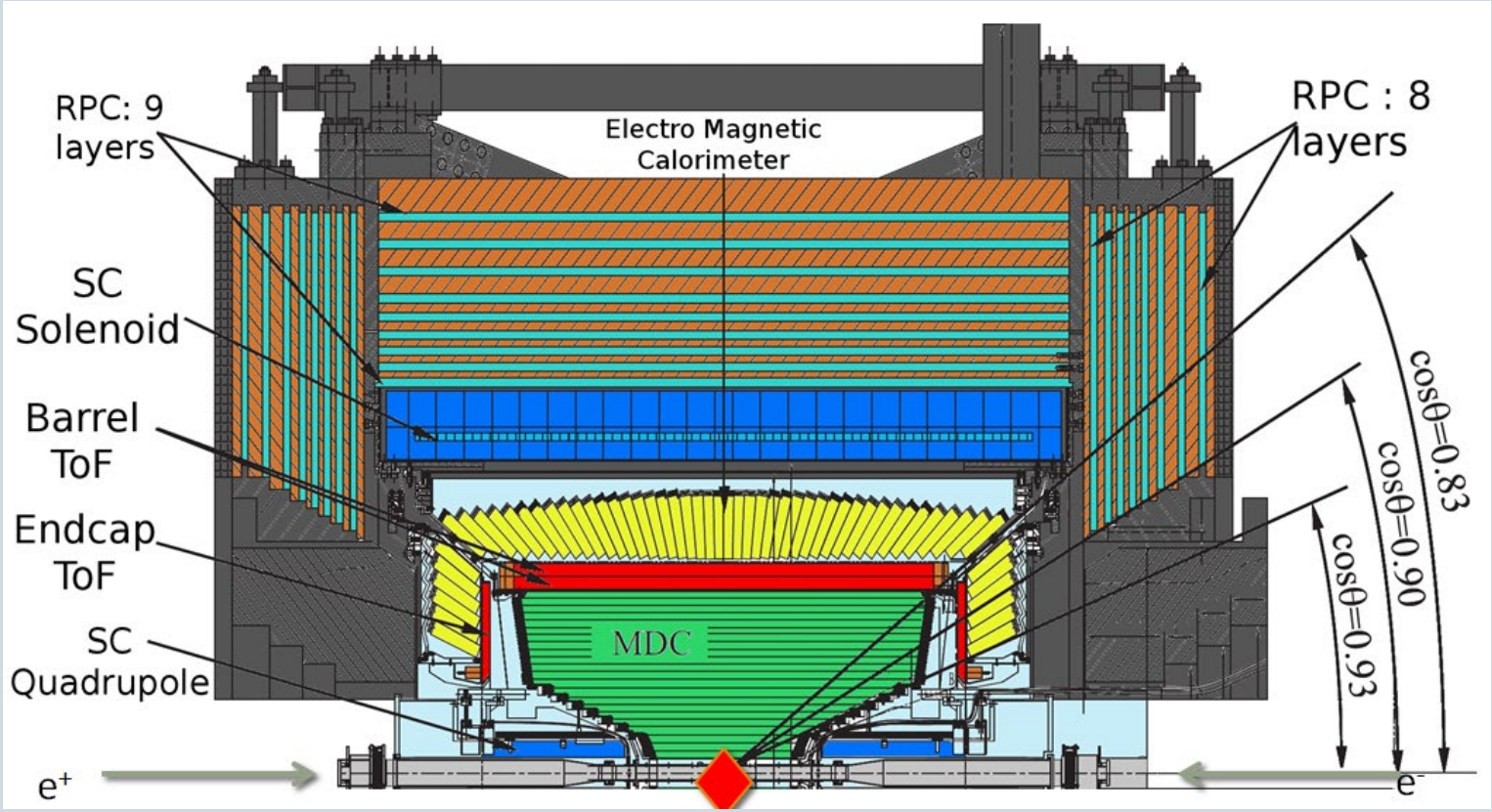
BEPCII 2008-now L_{peak}=1.0x10^{33}/cm^{2}s (April 2016)

E_{cm}: 2 — 4.95 GeV

BESIII

BESIII is designed to study physics in the tau-charm energy region.
BESIII has collected the J/ψ world largest data sample (10B).

It has been approved an extension of the data taking till 2030 (at least)



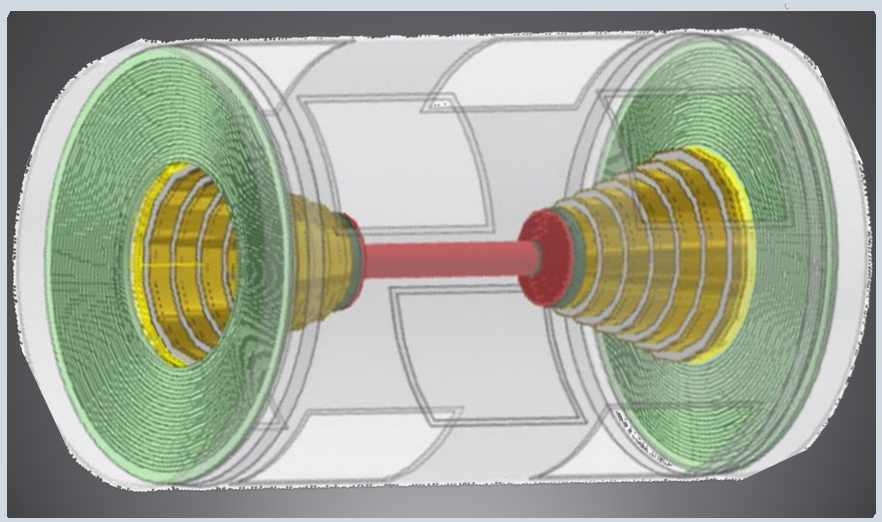
Total weight 750 tonnes, ~40,000 readout channels, Data rate: 5 kHz, 50 Mb/s

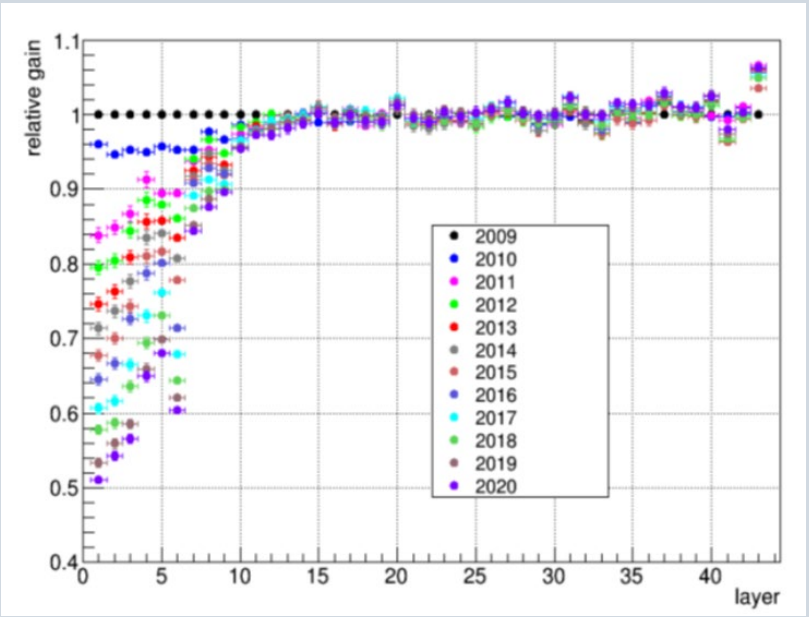
white paper on future physics program
Chinese Physics C, vol. 44, no. 4, 2020

MDC, 0.5% at 1 GeV/c
CsI(Tl) calorimeter, 2.5% @ 1 GeV
BTOF, 70 ps / ETOF, 60 ps
dE/dx 6% e^- Bhabha scattering

Inner Tracker

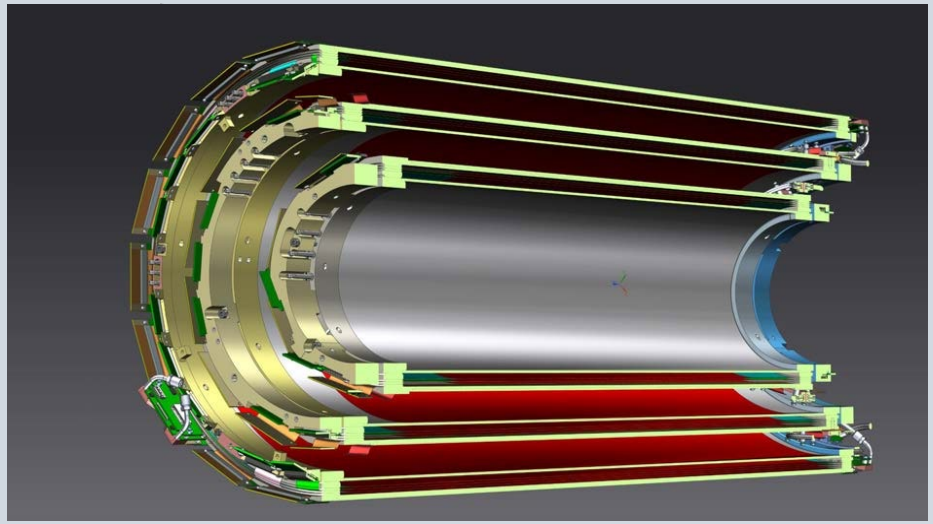
MDC>inner chamber

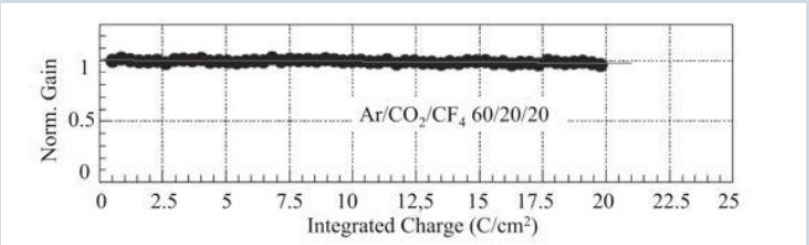




Aging
Gain loss/year
~ 4% on inner layers

CGEM> GEM technology



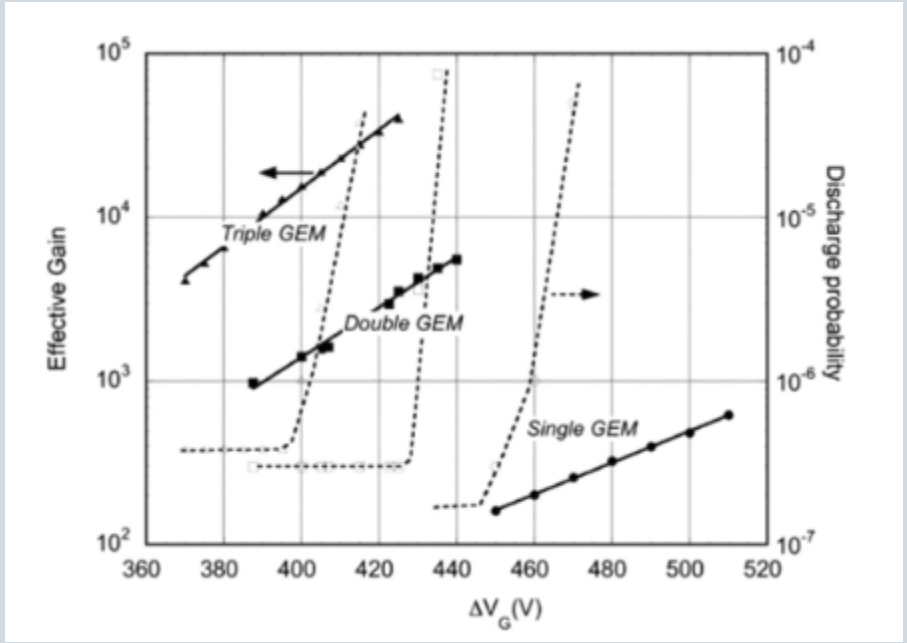


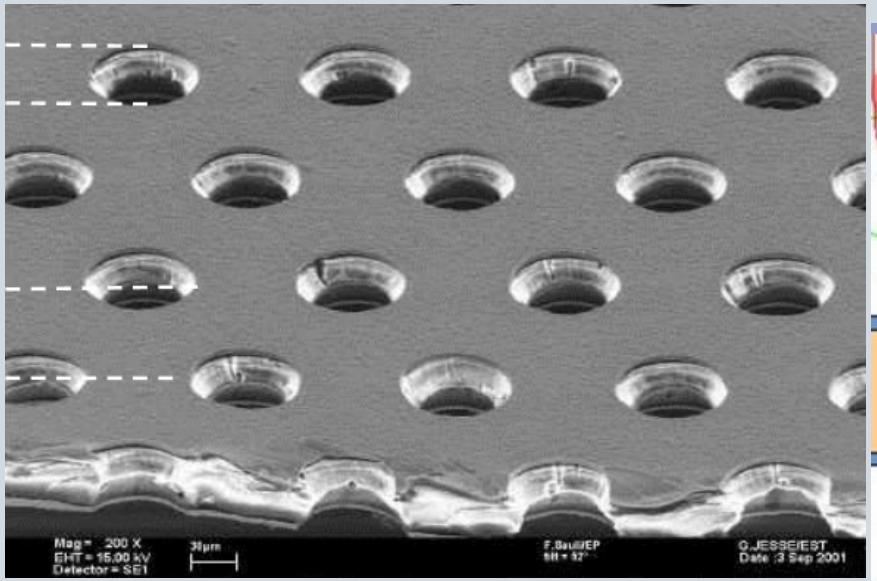
Low spatial charge
High rate capability
Fast response
Light support frame
Very low aging

GEM detectors

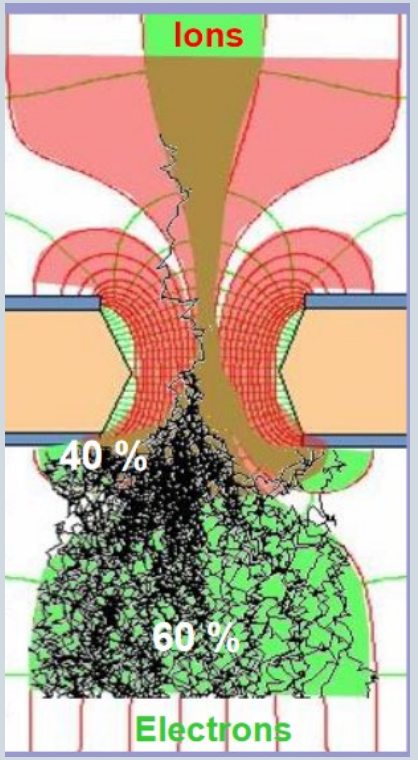
GEM (Gaseous Electron Multiplier) is a Micro Pattern Gas Detector, invented by Sauli in 1997

- High rate capability
- High radiation hardness
- Scalable and flexible geometry





NIMA 386, 1997



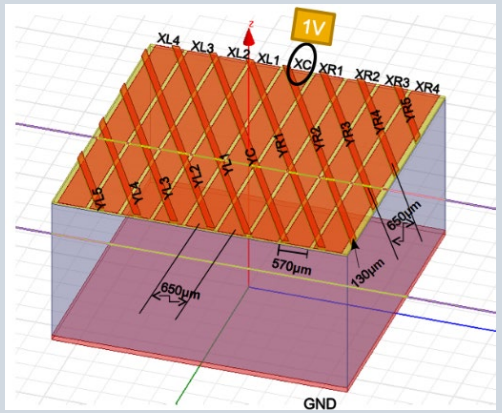
More layers of GEM grant high gain with lower applied voltages → lower spark rate

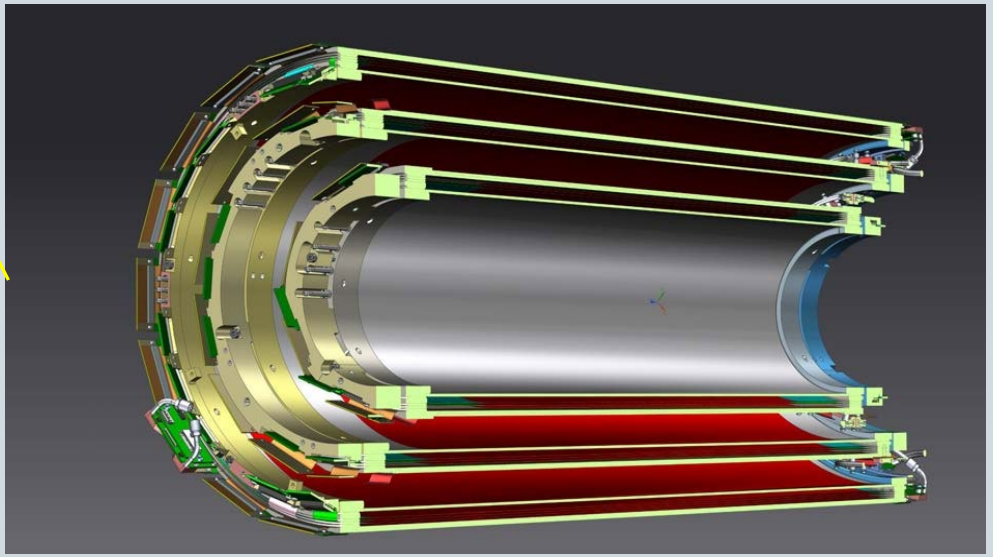
NIMA 805, 2016

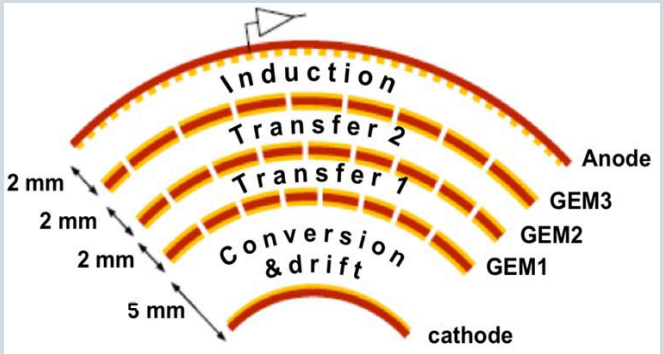
CGEM> Cylindrical Gaseous Electron Multiplier

- σ_{xy} ~ 130 µm
- σ_z < 1 mm (~ 350 µm)
- σ_{pt}/p_t ~ 0.5% @ 1 GeV/c
- Operation in 1T magnetic field
- Material budget $\leq$ 1.5% X_0
- High rate capability: 10^4 Hz/cm^2

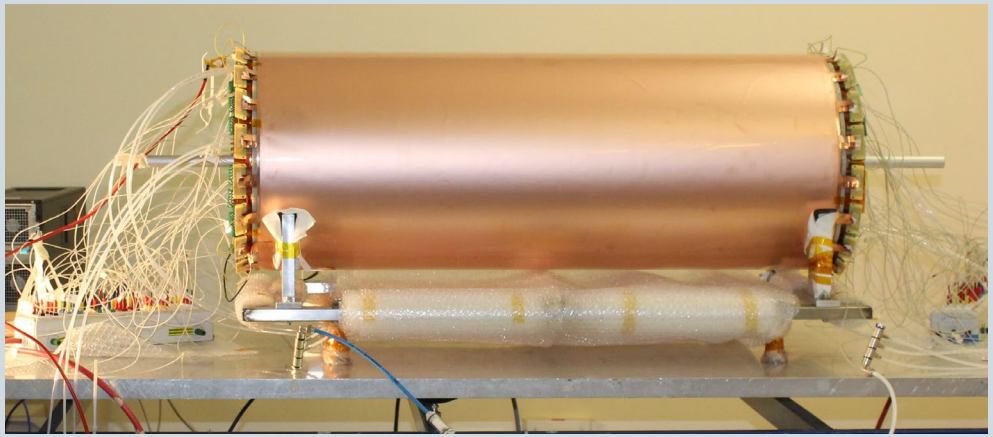
Three layers of cylindrical triple-GEM
Each layer has two "views" to reconstruct the 3D position of the hits



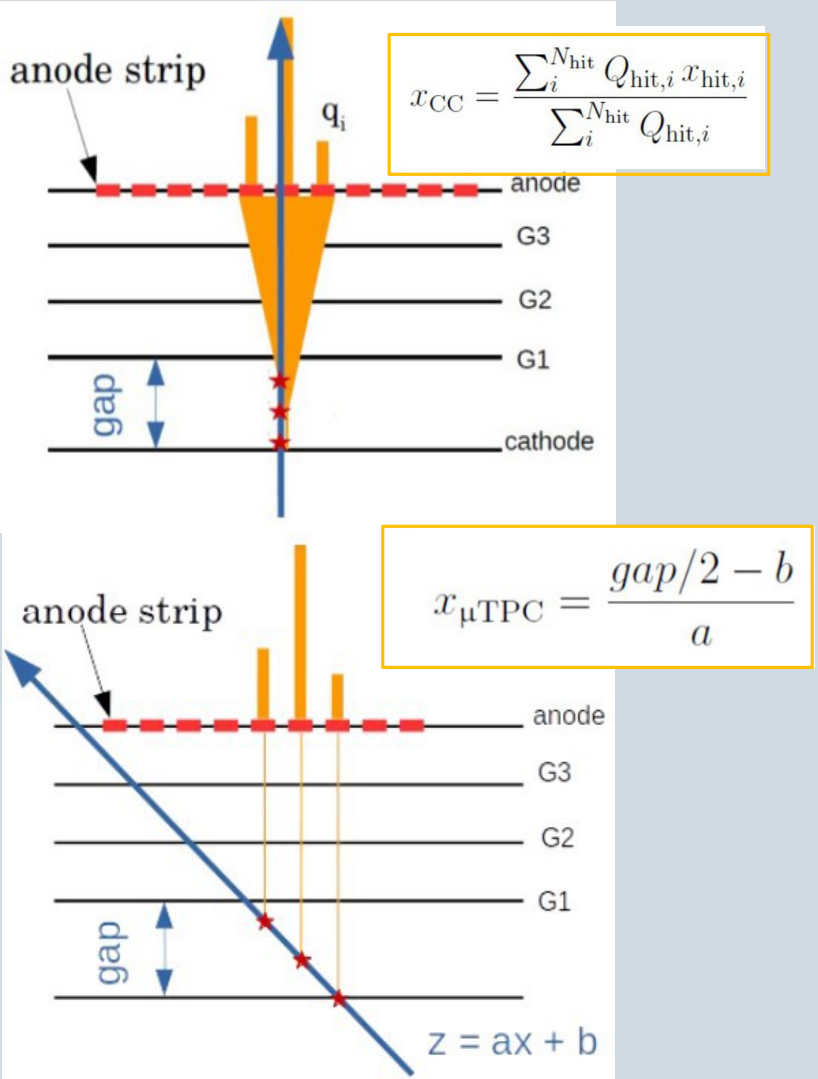


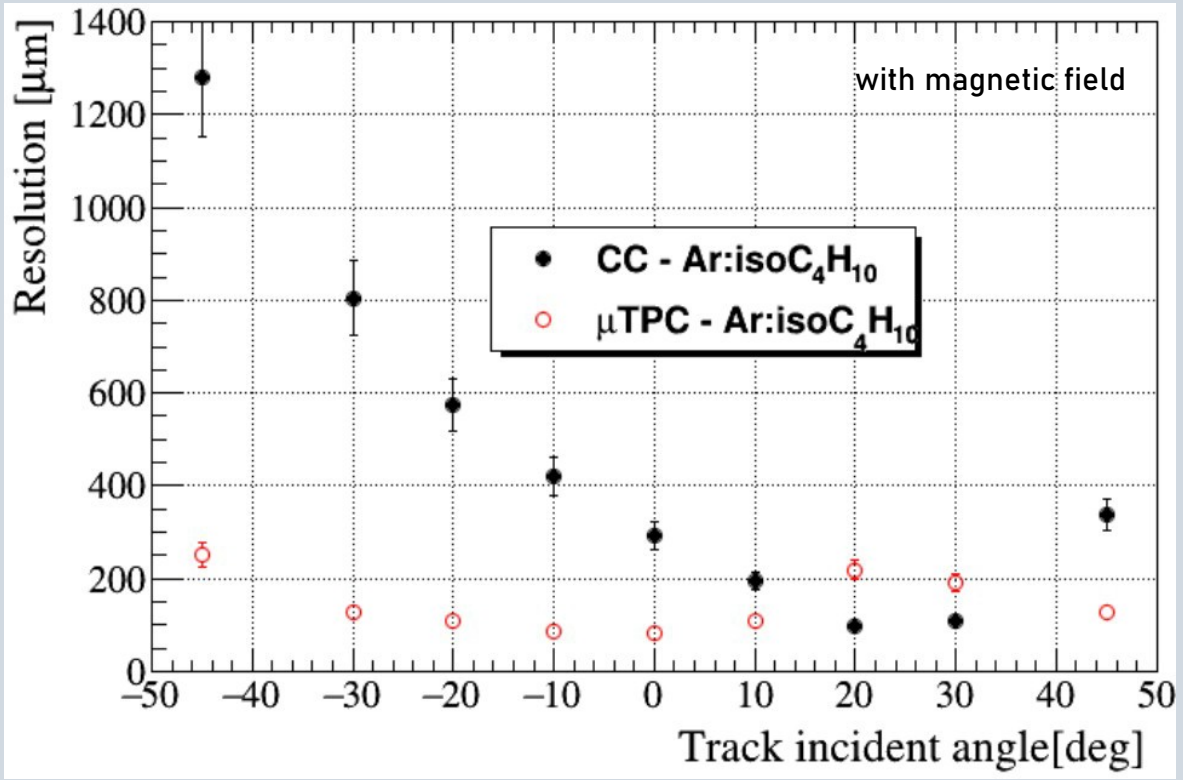


Ar-iC4H10 (90%-10%)
1.5/3/3/5 kV/cm



Position reconstruction

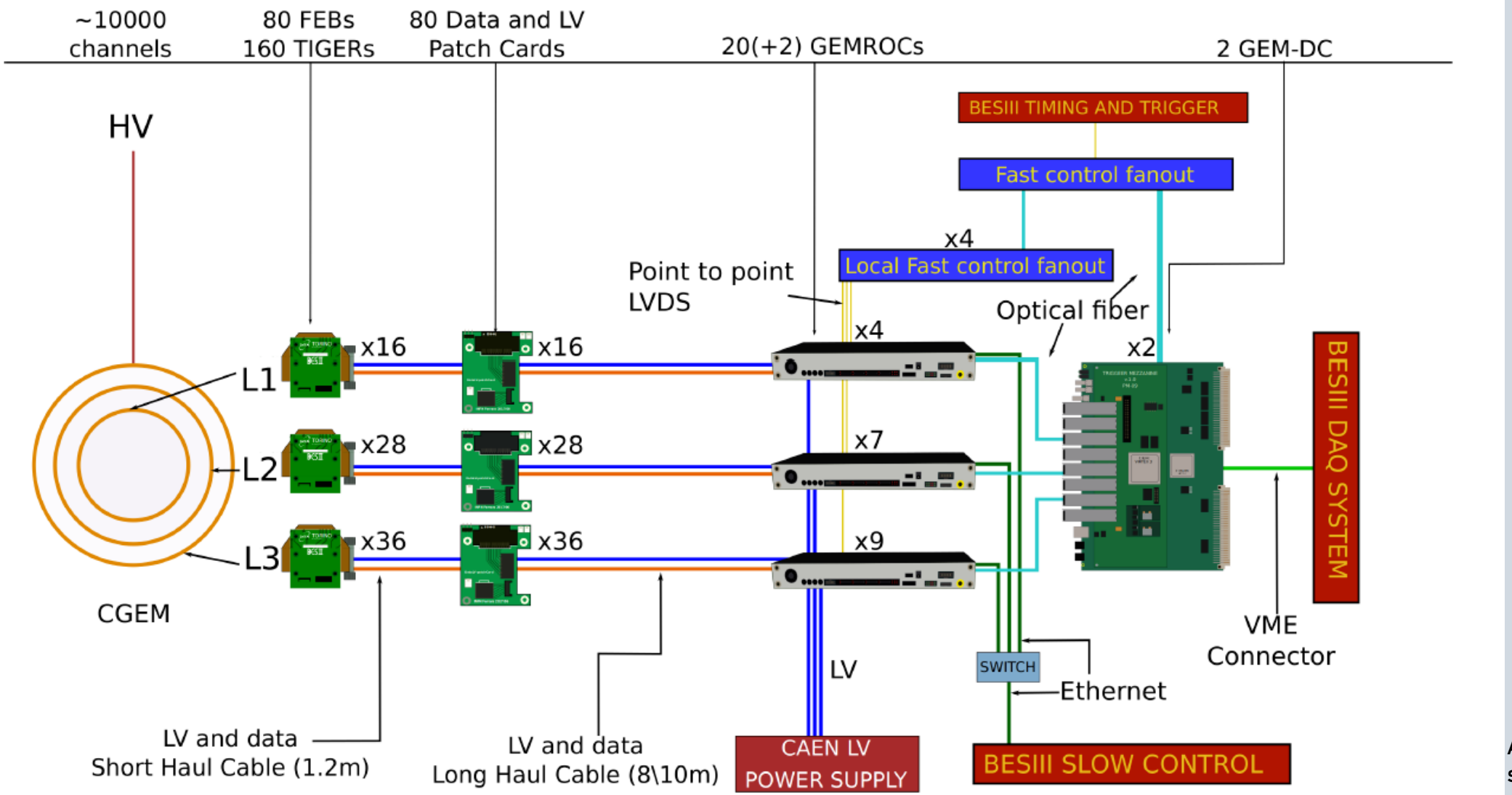




Contiguous fired strips on the anode form a cluster

M. Alexeev et al 2019 JINST 14 P08018
R. Farinelli PhD Thesis, arXiv: 1904.06548

Readout chain



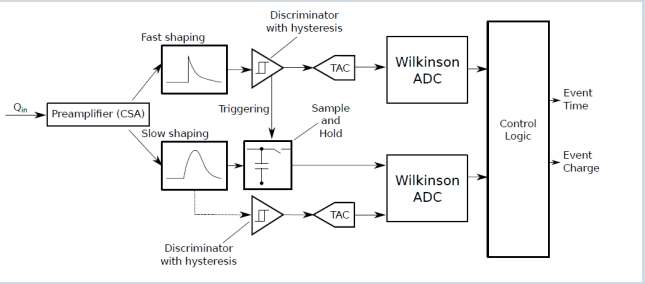
Article submitted to JINST

TIGER+GEMROC

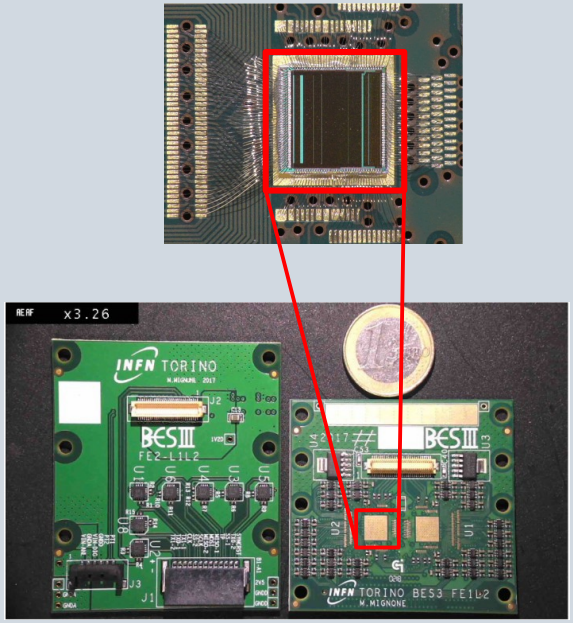
TIGER (Torino Integrated Gem Electronics Readout)
64-channels ASIC
charge and time readout

Sample & Hold
Time-over-Threshold

Parameters	Value
Input Charge	2-50 fC
Input Capacitance	Up to 100 pF
Data Rate	60 kHz/ch
Readout Mode	Trigger-less
Non-linearity	<1%
Charge Collection Time	60 ns
Time resolution	<5 ns
Power Consumption	<12 mW/ch
Technology	110 nm process



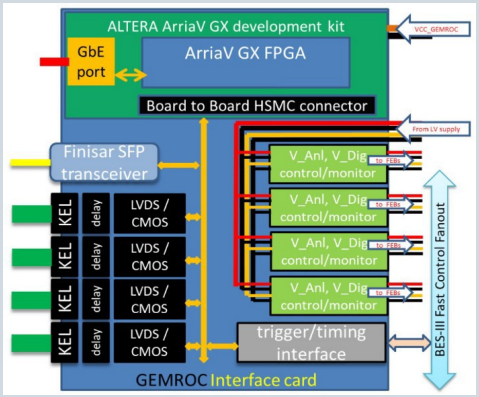
JINST 12 C07017



INFN-Torino

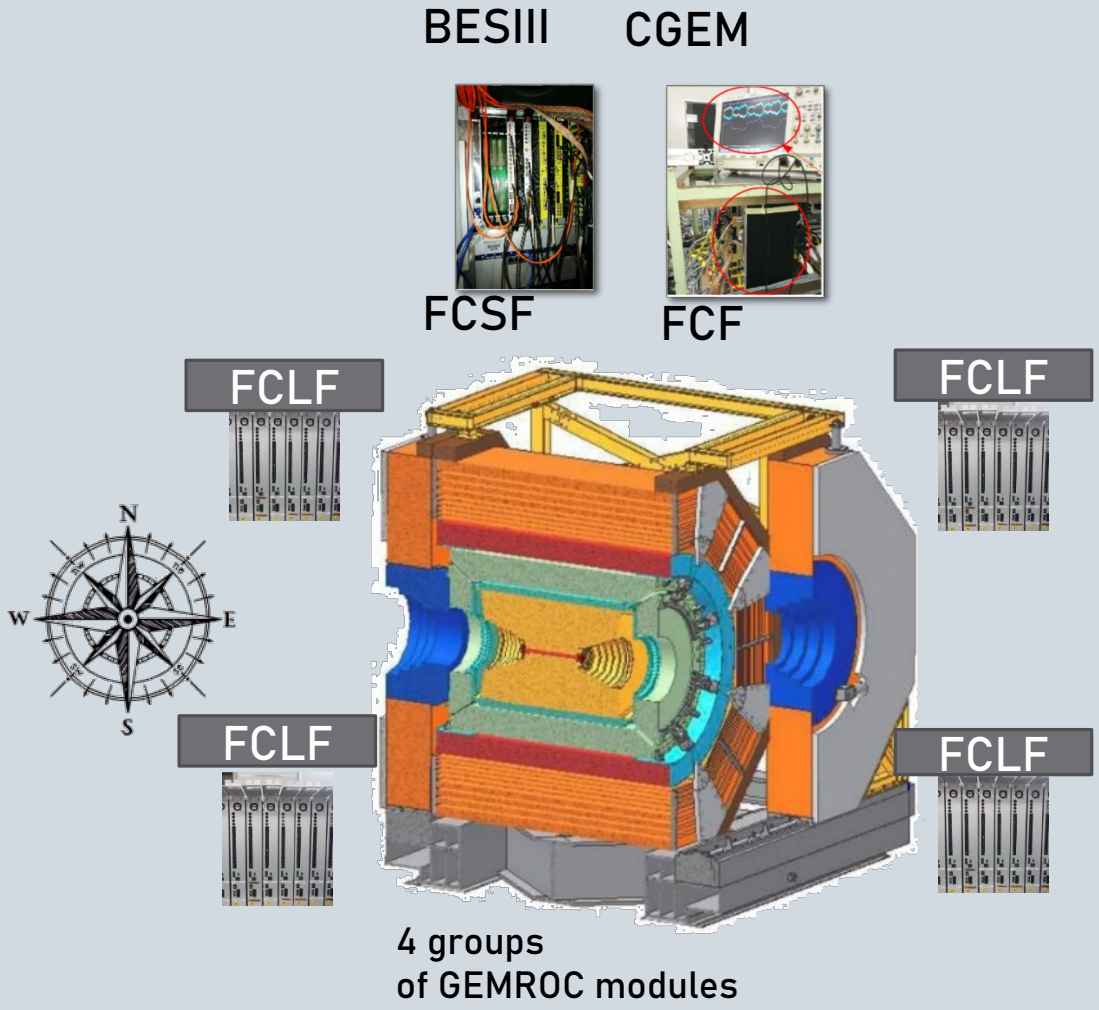
GEM Read Out Card

Power the FEBs
Monitor chips voltages and temperature
Configure the chips
Receive timing signals
Control data acquisition via optical links/Ethernet



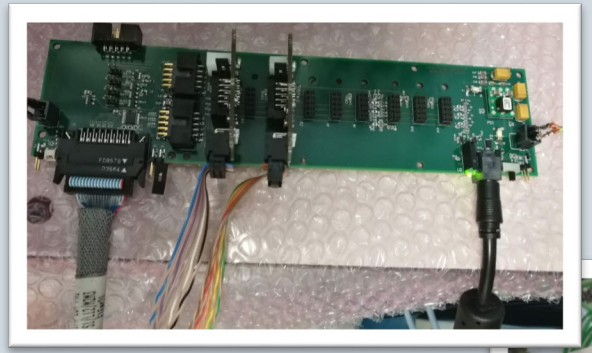
INFN-Ferrara

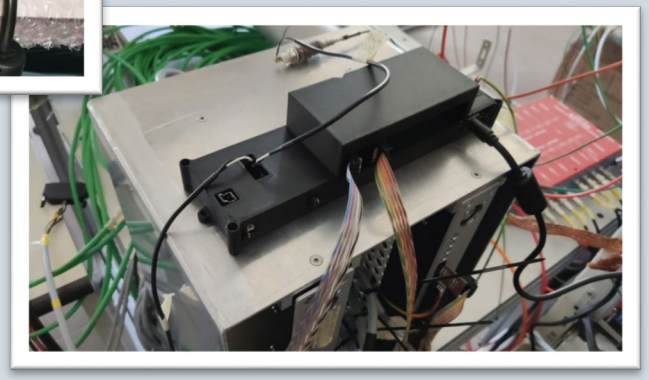
Timing signals



Fast Control system Fanout
a modified GEMROC module which connects to the CLK, L1, L1_CHK, FULL signals from the BESIII FCSF

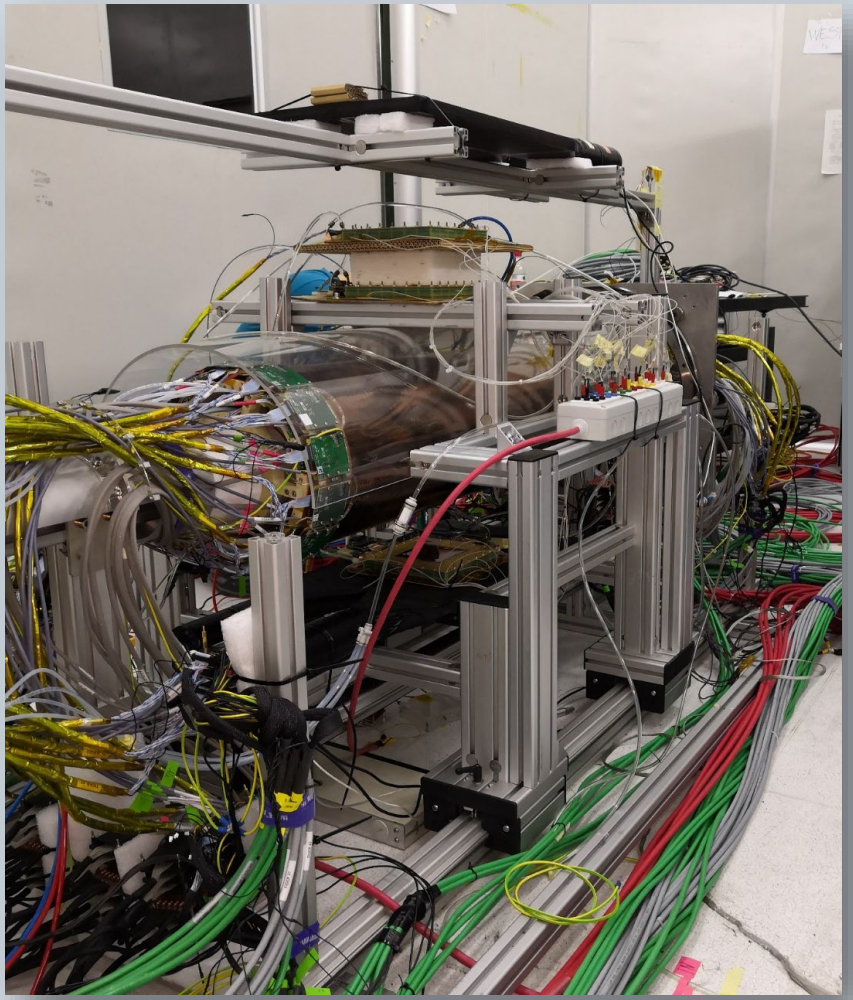
Fast Control system Local Fanout
a low cost, not programmable, fanout module which connects to the CLK, L1, L1_CHK, FULL signals from FCF





INFN-Ferrara

Cosmic setup in Beijing



On site operations carried out thanks to the BESIII MDC group

~5.6k channels connected
Final LV/HV systems

More than one year of data taking

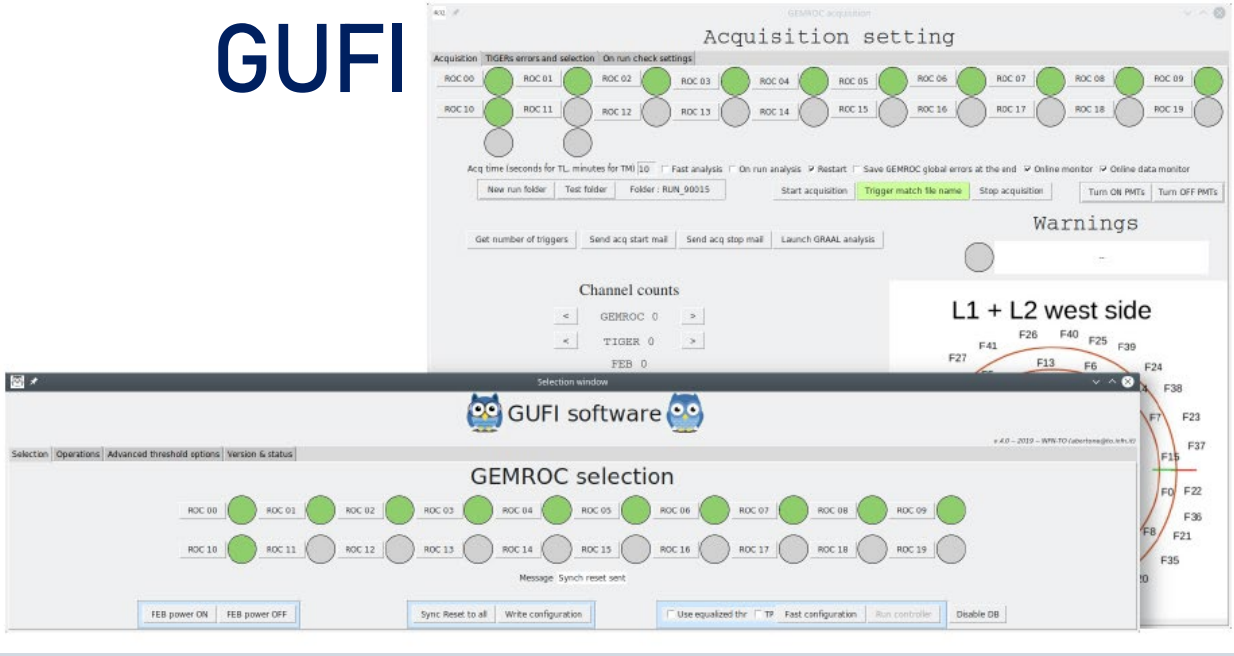
Remote data taking carried out by the Italian groups

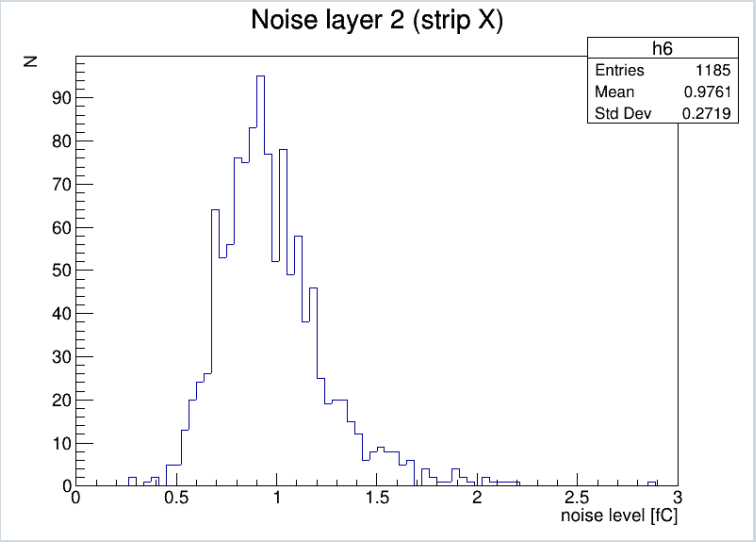
GUFI

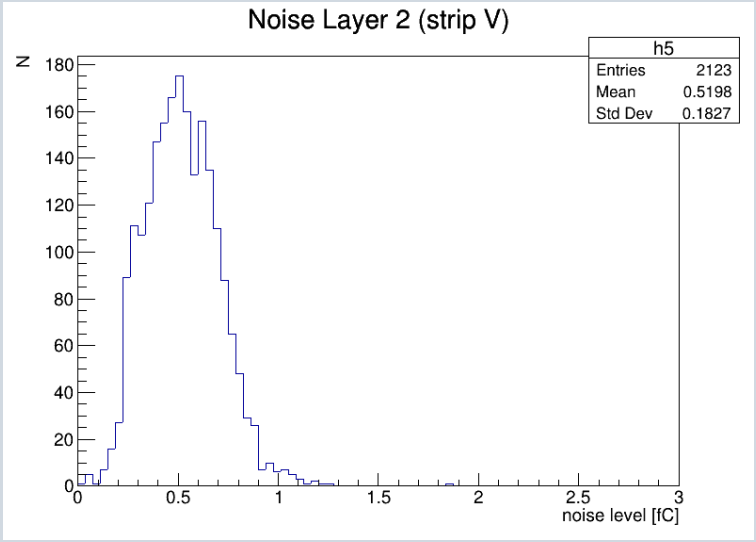
Graphical User Frontend Interface Python-based sw

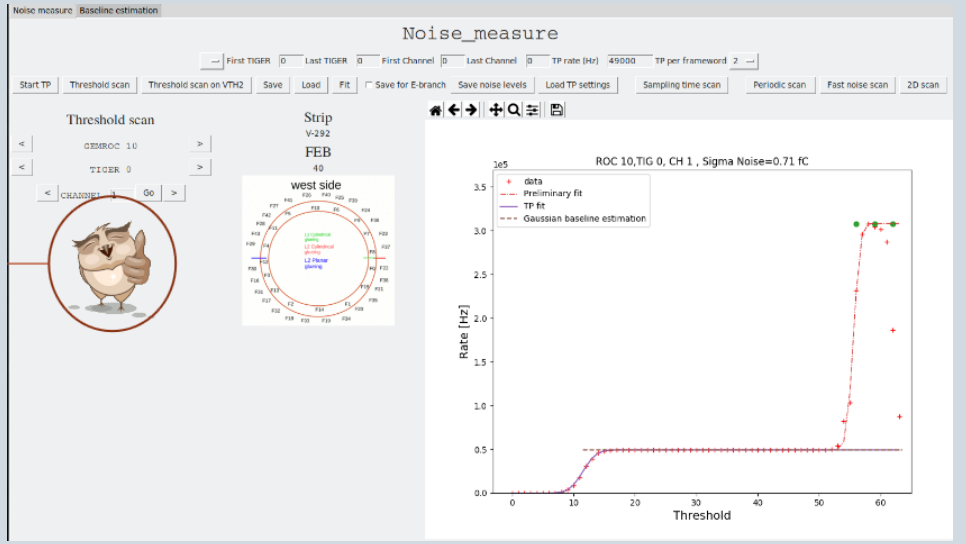
to characterize, debug and test the system before the installation

standard and advanced features



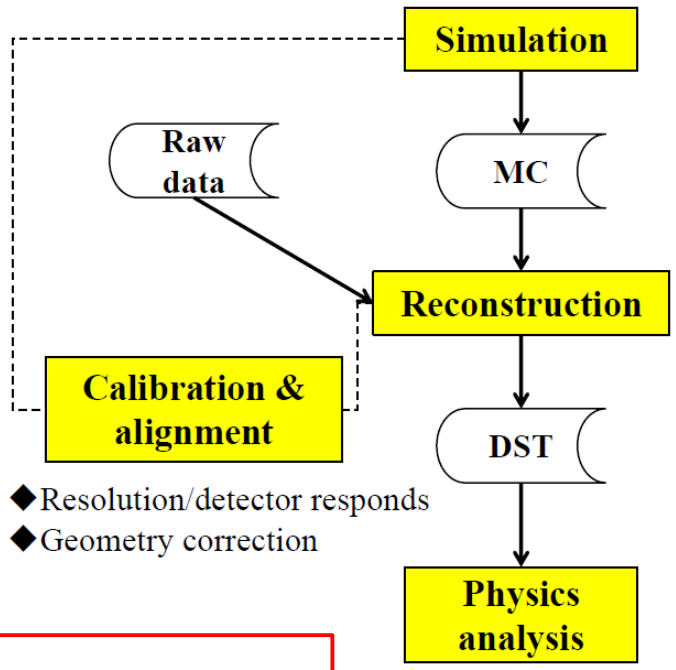






CGEMBoss

BESIII Offline Software

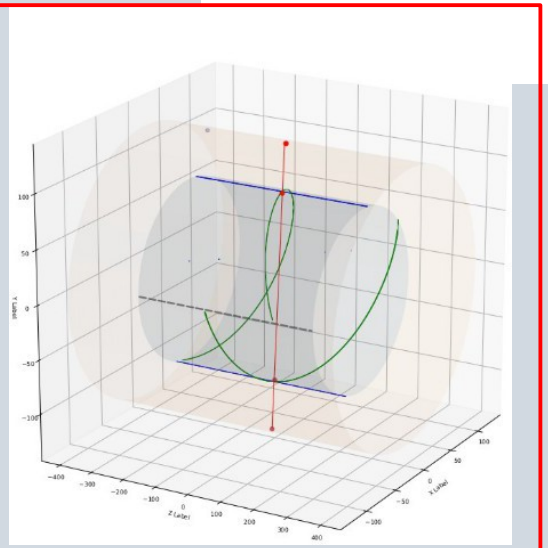


- Detector description (Geometry/material)
- Digitization

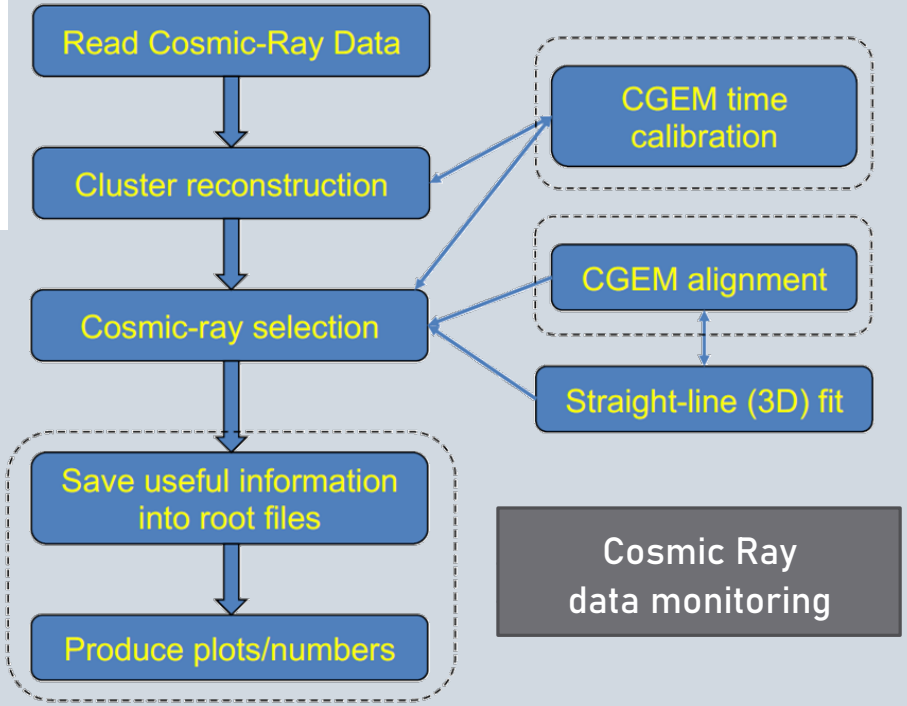
- Cluster reconstruction
- Track segment finding with CGEM
- Track matching
- Global track finding with Hough transform
- Track fitting

- Resolution/detector responds
- Geometry correction

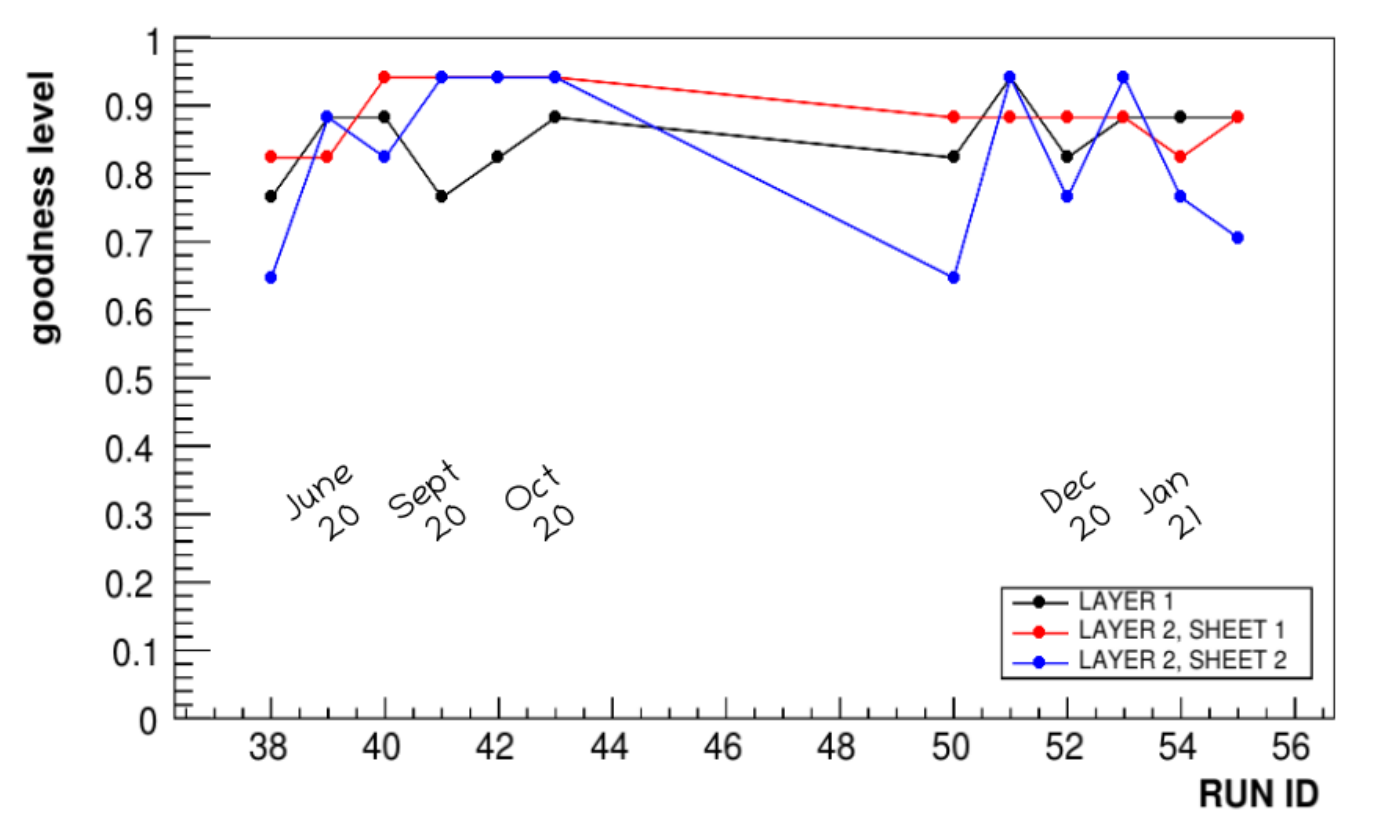
- performance check (efficiency, resolution ...)



Developed together with Chinese and American colleagues



CGEMBoss QA



A series of tests is performed on each layer/view in terms of hits-clusters 1D /2D -cluster size- occupancy- noise level

Limits are set according to a reference run (January 2020)

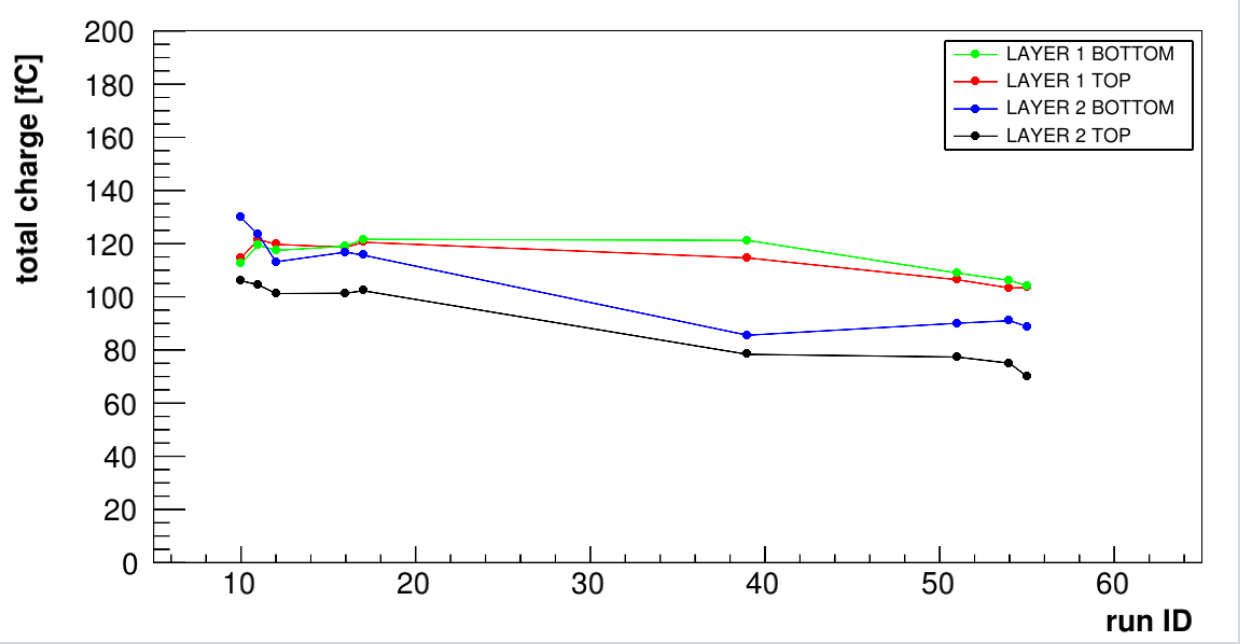
$$\text{Goodness} = \frac{\#passed\ tests}{\#performed\ tests}$$

Ar-iC4H10 (90%-10%)

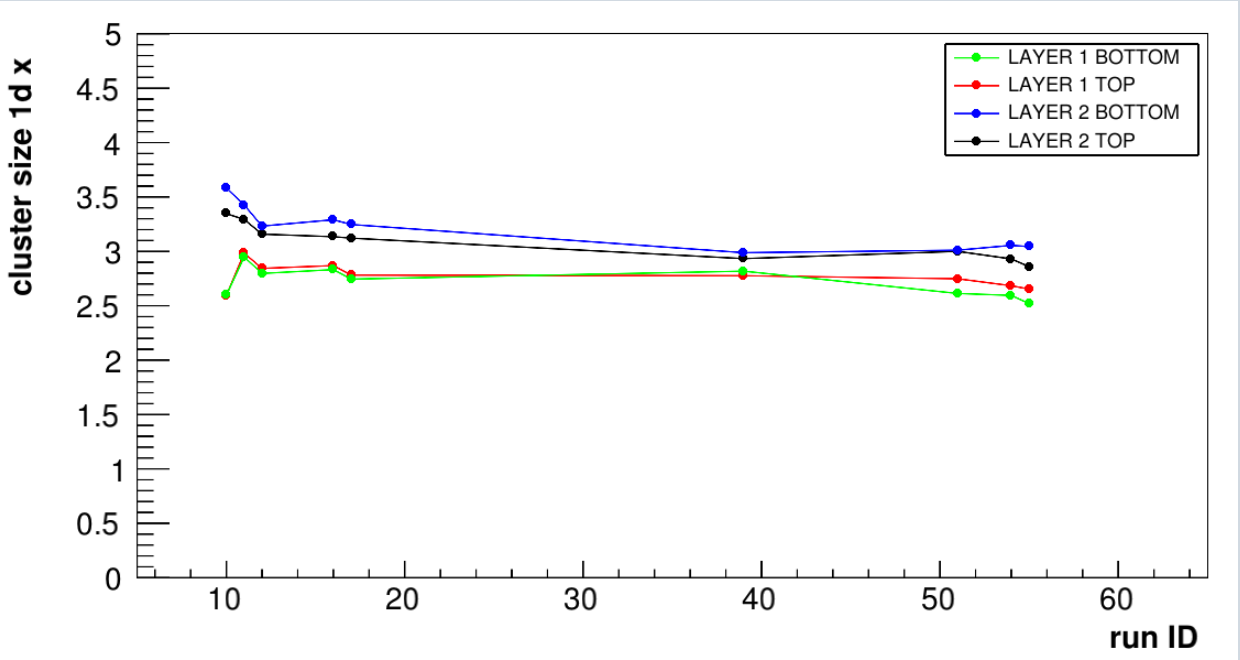
1.5/3/3/5 kV/cm

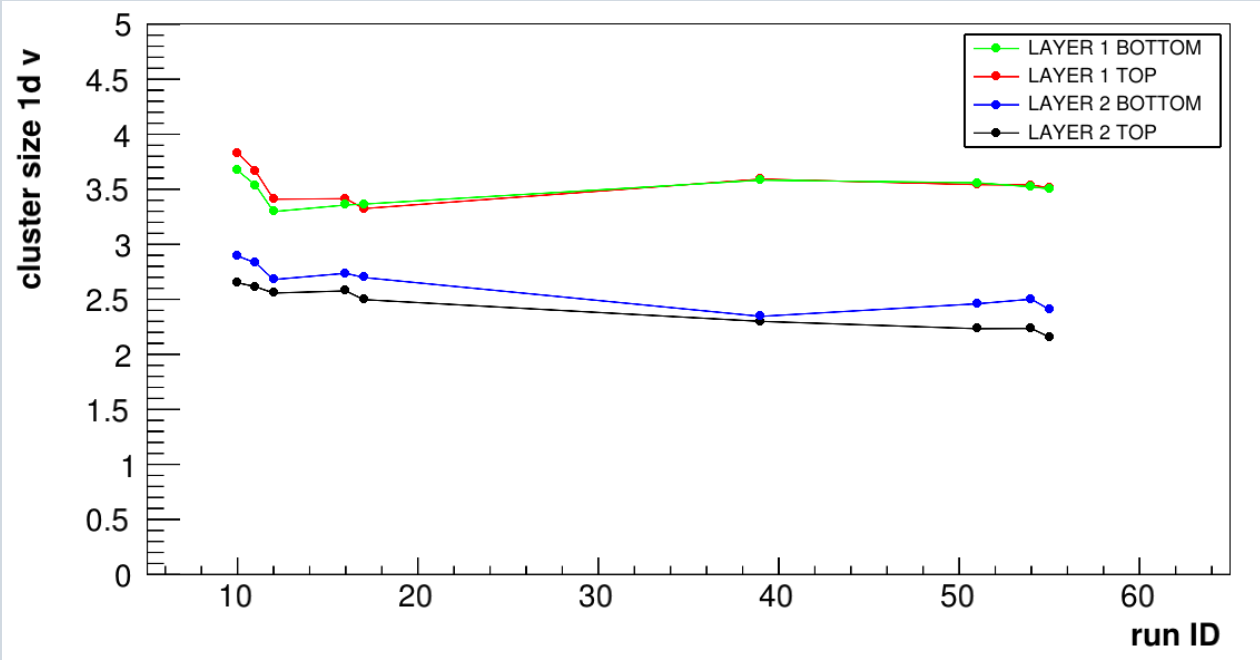
G1+G2+G3=835V

CGEMBoss QA

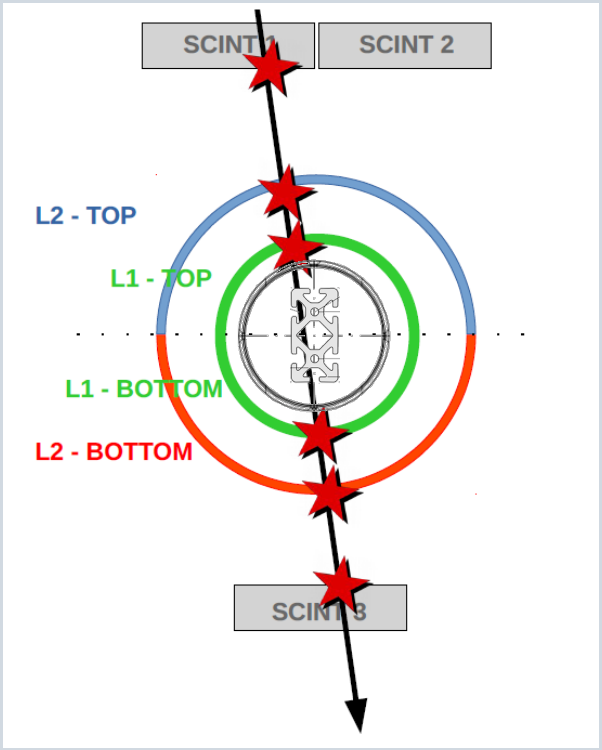


Overall stable condition

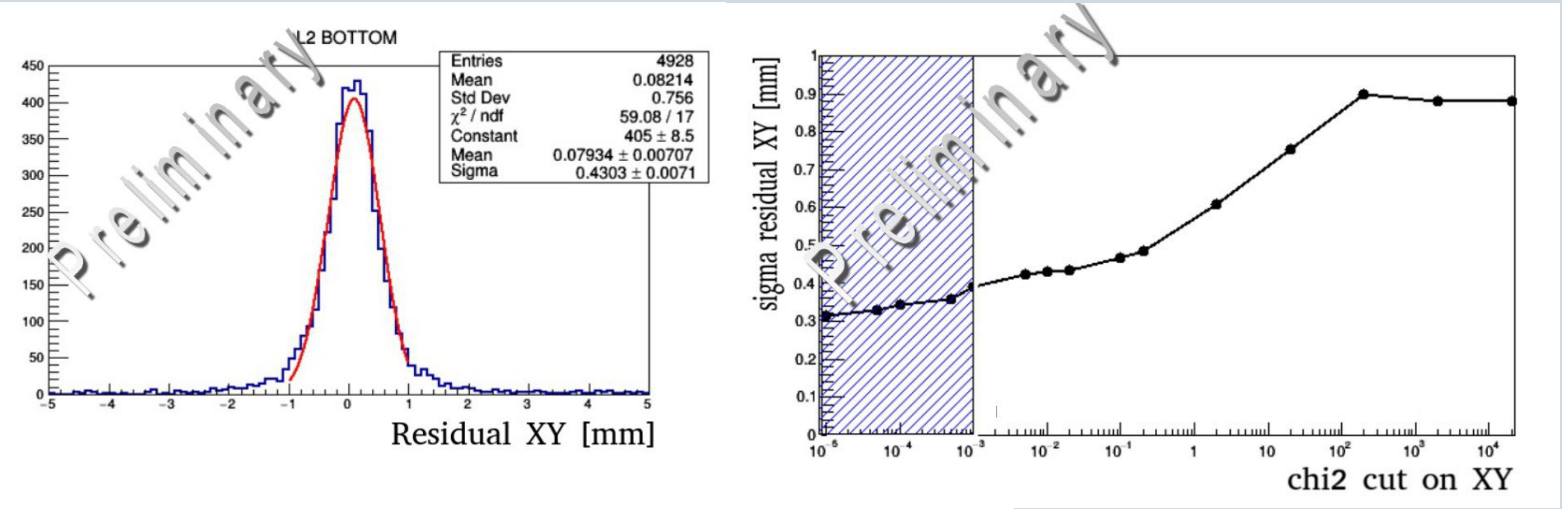


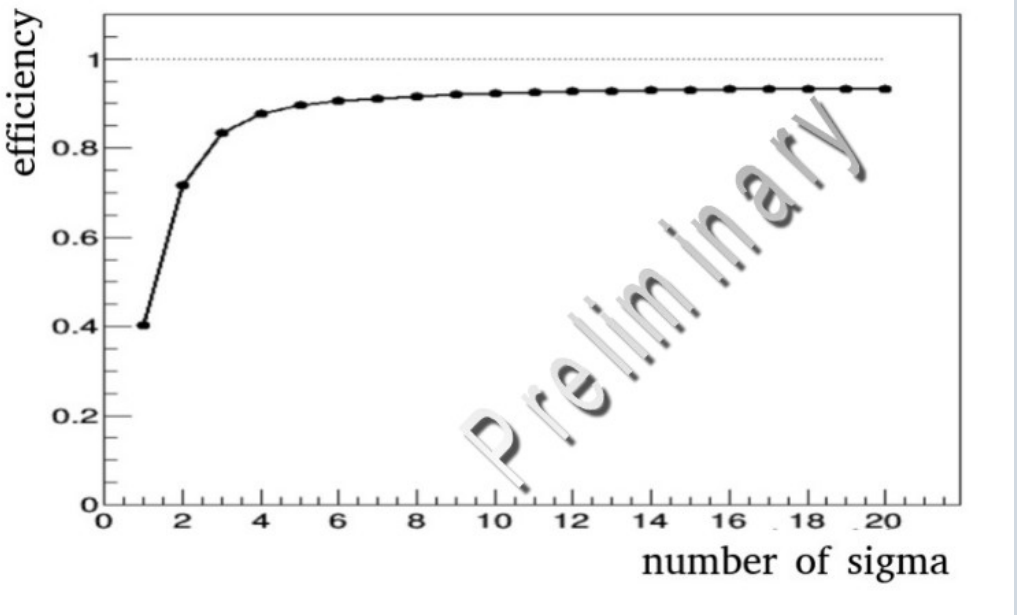


Preliminary results



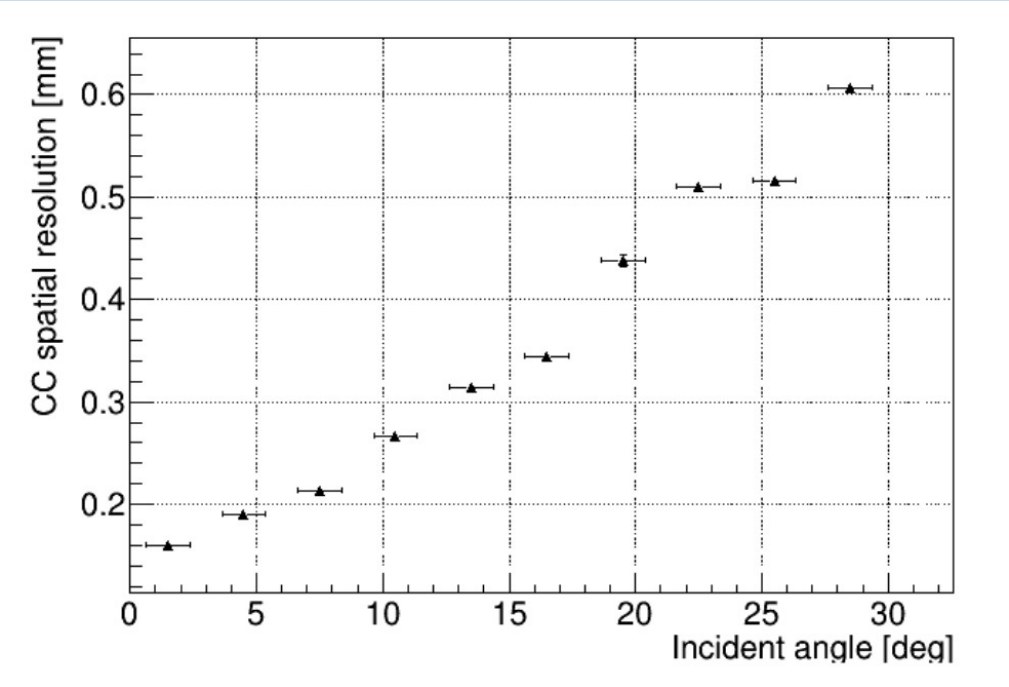
3D tracking with four planes

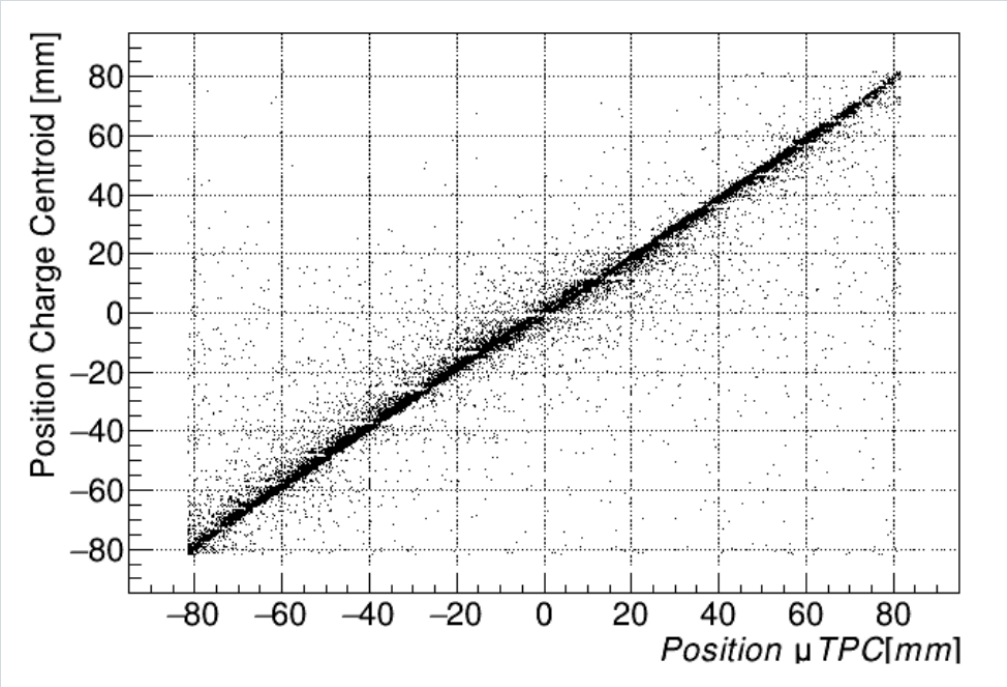




Plateau of efficiency ~ 90%

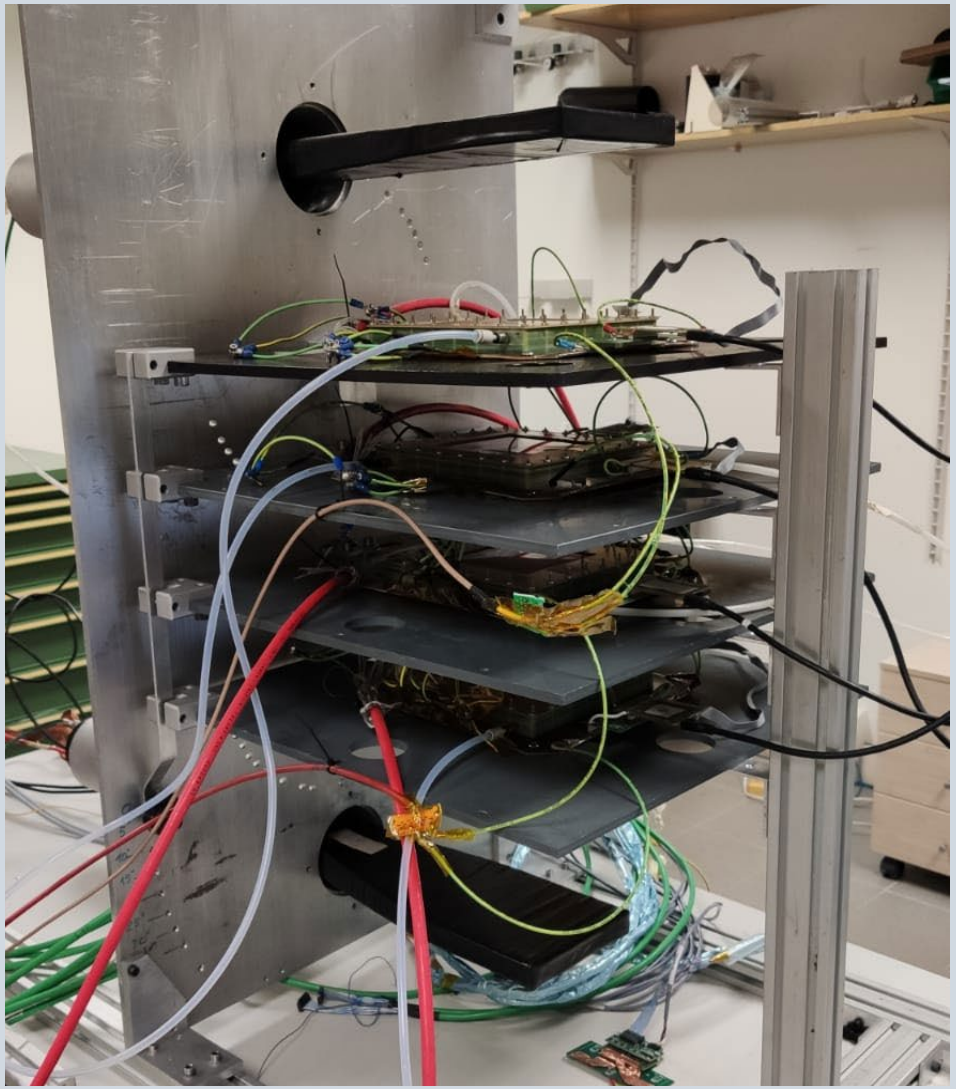
Preliminary results



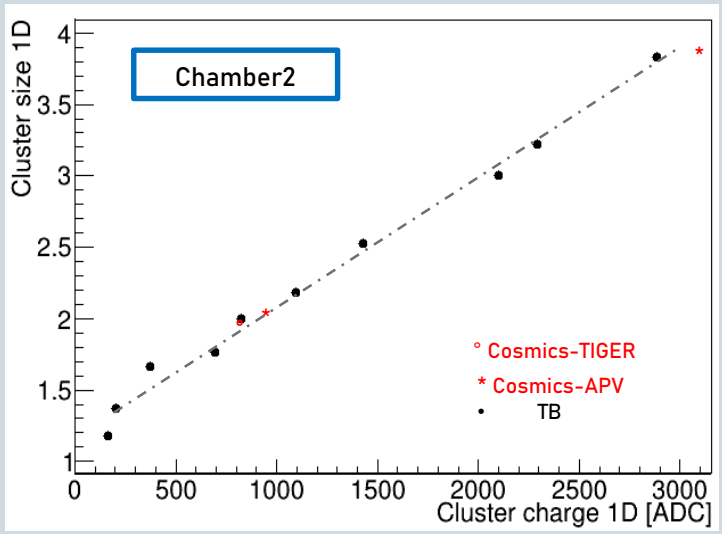


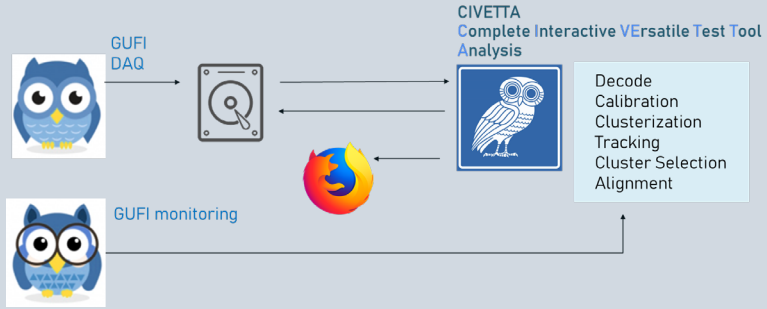
good agreement

In the meantime



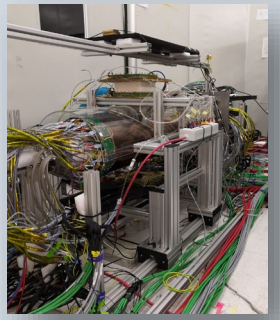
-Cosmic telescope instrumented with planar GEM chambers
- fanout modules
- benchmark with APV/SRS electronics done
- performance close to the beam test results
- tests with TIGER /GEMROC in progress
- good preliminary results





-working on the completion of the detector

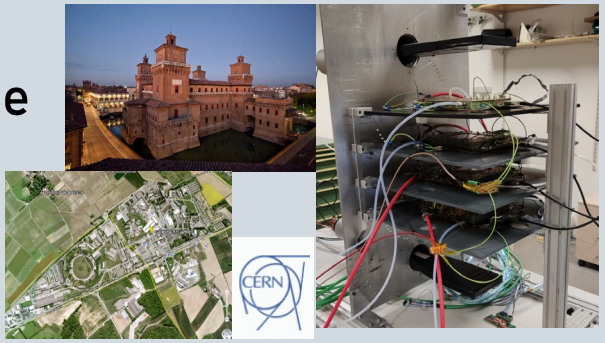
Outlook



When the pandemic spread, we did not expect to manage operations remotely for such a long period. Nevertheless, we were able to continue the CGEM detector characterization

Preliminary results with cosmic rays show good performance and an overall good stability.

In the meantime, we are working on the completion of the detector and preparing for a beam test at CERN, in July!



BESIIICGEM FEST

RISE

European Commission

HORIZON 2020

謝謝

thank you